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ABSTRACT

This paper reviews research that correlates student achievement and the condition and utility of school facilities. The discussion focuses on the influence of various facility conditions on students, including building age, temperature and ventilation, acoustics, lighting, curriculum development, and school size. Research shows that older buildings may pose a variety of negative consequences for the learning process, while safe and modern schools with controlled environments enhance learning. More specifically, students who attend better buildings have test scores ranging from 5 to 17 percentile points higher than students in substandard facilities. The paper concludes by quoting a recent report suggesting that a school's condition may have a stronger influence on student performance and achievement than the combined influences of family background, socio-economic status, school attendance, and behavior. (GR)

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A CEFPI Brief on Educational Facility Issues

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CEFPI BRIEF

Learning is a complex activity that supremely tests students' motivation and physical condition. Teaching resources, teachers' skill, and curriculum — these all play a vital role in a child's education. But what about the physical condition and design of the actual school facility itself? How do they shape a child's learning experience?

Today's busy parents may never know. With most of them working, parents generally find little time to experience, much less evaluate, the physical condition of their child's school. When they do visit, often during parent-teacher's night, discussions will mostly focus on their child's learning, achievement, and progress, not on school maintenance or design issues. There are few opportunities for parents to observe a classroom or school during the school day. But it is just during this time that a significant number of students and teachers struggle with such things as noise, glare, mildew, lack of fresh air, and hot or cold temperatures. About 40 percent of our schools report unsatisfactory environmental conditions.[1]

News about these environmental nuisances is beginning to appear more and more in the media. And research is uncovering growing evidence showing that conditions like these and many other aspects of school facilities have a huge and often negative impact on children's education.

Aside from superficial conditions like mold and mildew, that exist in schools often because of poor maintenance, other problems are much more systemic. One is age. The average school today at 42 years old, faces demands that were never intended or even conceived when the building was built. Another factor is that education today is delivered in an entirely new manner, with new tools, techniques, and teaching methods that increasingly don't fit the simplistic conventions of 42-year-old school designs.

There are about 91,000 public schools today, down from 262,000 in 1930. Student population, meanwhile, has grown from 25 million in 1950 to more than 47 million today. More than 75 percent of our schools were built before 1970 — three decades ago. By age 40, most buildings start deteriorating rapidly, even if all original equipment is replaced. Typical market forces suggest retiring our 42-year-old schools. But their service continues, perpetuating crowded classrooms, outmoded designs, poor communications systems, limited technology, and inadequate security.

Many older schools can't meet Americans with Disabilities Act accessibility requirements without extensive and often expensive renovation. Moreover, their static, inflexible design can preclude the use of advanced teaching processes such as peer-to-peer and group participation. These highly interactive group learning experiences, which have overshadowed the decades-old lecture/listen style of learning, are mandated in the evolved, technologically-driven working environment that students are preparing for. The core of this teaching approach requires school designs that have open, flexible floor plans; modular furniture; and highly mobile learning tools such as electronic chalkboards, portable computers, expandable networking, and interactive video. Few 42-year-old schools' designs can fill these needs. And the difference to a child between receiving an education in a really well-designed, modern new school and a typical 42-year-old school can be compared to the difference between writing in the sand and surfing the Internet.

EF 006 033

[1] *Condition of America's Public Facilities: 1999 U.S. Department of Education , National Center for Education Statistics, NCES 2000-032*

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Problems with older schools have been met by a flurry of critical reports and an infusion of funding. Figures on capital outlay for school construction from the National Center for Education Statistics show a 66 percent increase between 1994 and 1999. The Federal Government has initiated a one-year state grant program for emergency repairs and renovation to the neediest school districts.** But momentum is against finding a simple, fast solution.

School Facilities Can Breed Trouble

There are adverse yet solvable environmental conditions in many school facilities today that are particularly troublesome because of their very real and negative impact on learning. The first is asthma, a chronic disease of the body's airways accounting for a half-million hospitalizations and 5,000 deaths each year. The number of asthmatic children increased 60 percent in the 1980s. Asthma affects 29 million people, more than 4.8 million of them children, and costs $3.6 billion annually. By 2020, according to the Centers for Disease Control and Prevention, 60 million Americans will suffer from chronic respiratory diseases.[2] One in five Americans spends at least part of the day in a school building. In February 1995, the U.S. Government Accounting Office released a survey indicating that more than half of U.S. schools have deficiencies that adversely affect indoor air quality[3]. In addition to triggering asthma attacks in susceptible children, poor indoor air quality causes drowsiness, inability to concentrate, and lethargy. Whether poor air quality forces students to actually miss class because of asthma attacks, or whether it simply reduces attentiveness, learning is compromised.

Schools have four times as many occupants per square foot as offices, and they contain a host of pollution sources, including lab chemicals, cleaning supplies, chalk dust, and molds.[3] On any given school day, a significant percentage of students are absent for extended periods either from the school or the classroom. The U.S. Environmental Protection Agency (EPA) states that asthma is the leading cause of school absenteeism due to a chronic illness, accounting for over 10 million missed school days per year. The American Lung Association states flatly that asthma is the leading cause of school absences.

Asthma also accounts for interrupted sleep, limitation of activity, and disruption of family and care-giver routines. Asthma symptoms that are not severe enough to require a visit to an emergency room or to a physician can still prevent a child from living a fully active life. EPA's Science Advisory Board has consistently ranked indoor air pollution among the top five environmental risks to public health.[4]

The recently completed Cincinnati Asthma Prevention Study found that indoor irritants, long suspected of influencing rising asthma rates in young children, could be the key to asthma problems for four out of ten children.[5] Perhaps there is a significant potential for reducing asthma problems in the classroom and beyond if school air quality can be maintained at a healthy level.

Temperature and Ventilation Concerns

Related to troubling asthma problems in schools are concerns about temperature and ventilation. Faulty classroom temperature and air circulation are two of the worst problems in schools today. They may be caused by poor design, but often stem from subsequent construction changes, inadequate maintenance and the fact that many schools' heating, ventilation, and air conditioning (HVAC) systems are simply inefficient and outdated.

A good ventilation system is an effective means of keeping both toxic and nuisance materials out of the air. Indoor ventilation problems began attracting attention during the energy crisis of the 1970s, when buildings were sealed more tightly to reduce air leakage and minimize costs required to heat or cool air drawn in from outside. Problems associated with this energy crisis are still with us. The EPA recently concluded a study of human exposure to air pollutants. It indicated that indoor levels of pollutants may be two to five times higher than outdoor levels and sometimes even 100 times higher.[6] Common practice among building owners during the 1970s was to decrease ventilation rates from 15 cubic feet per minute per person, a standard recommended

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** *Approximately $1.2 billion has been appropriated by Congress under the Omnibus Appropriations Act Section 321, P.L. 106-554) for emergency repair and renovation of high poverty and rural schools and other school systems with special needs.*

[2] *New York Times, October 18, 1999, p. A1, A18, Poor People Are Fighting Baffling Surge In Asthma*

[3] *U.S. General Accounting Office, School Facilities: Condition of America's Schools, GAO/HEHS-95-61, February 1995*

[4] *In Focus: Clean Air, Efficient Energy Use, American Association of School Administrators, Spring 2000*

[5] *Washington Post, Health Section, Quick Study Section, March 6, 2001, p. 18, Common Household Allergens May Contribute to Asthma in Children*

[6] *Airing it Out, Ted Fitzemeyer, Page 20-25, American School and University, October 2000*

by the American Society of Heating and Refrigeration and Air-Conditioning Engineers (ASHRAE), to an average of 5 cubic feet per minute per person. Imagine the effect on learners in rooms where the air exchange is reduced by two-thirds, while maintenance remains absent or sporadic at best.

Not all children suffer the same way when air inside a classroom becomes unhealthy or marginally so, yet children as a group are considered most vulnerable to environmental contaminants because they have higher breathing and metabolic rates than adults and less fully formed biological defense mechanisms.[7]

Good Acoustics Vital for Learning

Good acoustics are important in any learning situation, but noise in classrooms often makes children struggle to hear and concentrate, defeating the learning process at the outset. In a typical school, classrooms may bombard students with three sources of noise:

1. Noise from outdoors.
2. Mechanical noise generated between rooms or between corridors and rooms.
3. Noise generated within the classroom, including the ventilation system.

Taken all together, the noise can stifle a child's chance to learn.

At any one time, 15 percent of students in an average classroom suffer a hearing problem that is either genetically based, noise-induced, or caused by infection.[8]

Students require a higher level of acoustic quality than adults, and to attain the good speech recognition necessary for optimal comprehension and learning, classrooms must limit background noise, carefully manage reverberation of sounds, and keep outdoor noise to a minimum. But schools and their classrooms in particular generally have hard walls and floors, which create poor acoustics.

A study in Tennessee shows that children with a slight hearing loss are more likely to repeat a grade than students with normal hearing. Typically, children don't fully develop the ability to sort sounds from background noise until well into their teen years. Further studies have linked a student's hearing problems to being held back a grade.[9]

Even low-level noise in an open office setting produced higher levels of stress, a study found in the October 2000 issue of the *Journal of Applied Psychology*. A study from Cornell University found that students who had to put up with airplane noise in class don't learn to read as well as students who learn in a quieter environment. Cornell researchers Lorraine Maxwell and Gary Evans, who compared first- and second-graders at two New York City schools, found that students attending the quieter school scored as much as 20 percent higher on a word recognition test than students who learned with noisy airplanes flying overhead.

There are literally thousands of schools located in areas of high noise. How do young children whose senses are still developing cope with the background din that permeates some classrooms because of internal or external factors?

Full-Spectrum Lighting Essential

Natural light has a profound influence on our body and mind. It affects our circadian rhythm — our body's natural regulating biologic system, which governs all activities. It can alter our mood and is a major source of Vitamin D, required for strong bones and healthy teeth.

"Daylighting in Schools," by Heschong Mahone Group in Fair Oaks, Calif., is a detailed new study investigating the relationship between daylighting and human performance that involved thousands of students from more than three states.[10] The study's initial report shows that students in a classroom that had a well-designed, adjustable skylight that diffused daylight throughout the room and reduced glare, improved their learning

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[7] *National Institute of Environmental Health Sciences. 1999. Children's Enviromental Health and Disease Prevention Research. Environmental Health Perspective 107 (Supplement 3, June 1999)*

[8] *Niskar, A.S., Kieszak, S.M., Holmes, A., Esteban, E., Ruben, C. & Brody, D.J. (1998). Prevalence of hearing loss among children 6 to 19 years of age, Journal of the Amencan Medical Association 279(14), 1071-5*

[9] *Bess, F.H., Dodd-Murphy, J. & Parker, R.A. (1998). Children with minimal sensonneural hearing loss. Ear and Hearing, 19(5), 339-54*

[10] *Day lighting in Schools - An investigation into the relationship between day lighting and human performance was prepared for Pacific Gas & Electric Company and funded by California utility customers under the auspices of the California Public Utilities Commission. HMG Project #9803, July 21, 1999*

substantially faster than students in more traditional classrooms. Though criticized because the initial report lacked control for teacher quality — one of the main determinants for student achievement — the final study report will incorporate this control factor.

Other reports on use of natural light, including the one by Warren E. Hathaway called "Effects of School Lighting on Physical Development and School Performance,"[11] clearly show that the visual environment is one of the most important factors in learning, affecting mental attitude, class attendance, and performance.[12]

Links Between the School Facility, Society, and Educational Outcomes

Study after study concludes that there is an explicit relationship between the physical characteristics of school buildings and educational outcomes. And while good maintenance, modern systems, and flexible designs are clearly required, there are even more complex, outside societal factors that need to be addressed.

Parents and society are demanding more accountability and uniform standards in evaluating student achievement. Parents in particular want to be able to evaluate their child's learning achievements and academic standing among other students.

Educators have reacted by lengthening school schedules and requiring longer school days and shorter vacation times. Efforts to improve student learning have also resulted in stricter achievement standards and more student testing. All of these changes and trends are necessary in this technological age and they are here to stay, even at the earliest grade levels. And even though the student population will continue to grow for several more years[13], the goal to reduce class size has been set in many areas of the country.

Generally our student population is becoming more multi-cultural. Teachers will need to continue to ensure that their individual teaching styles encompass students' diverse cultural needs. Emphasis on math and science will continue to be essential for a proper education. Teachers are becoming more involved in team teaching, where individual teachers share a common theme with students. Some school systems allow teachers to stay with the same student through several grade levels.[14]

Linkages between different subject areas are growing, and teachers, of necessity, are enhancing their multi-disciplinary capabilities. Students are becoming increasingly collaborative, working in groups to obtain a common learning goal.

All these changes in teaching methods require changes in school facilities. The old adage, "the building fits the curriculum," a saying that developed because the physical structure limited the learning experience, no longer holds true. School facilities and classrooms can be flexible enough to accommodate changing learning patterns and methods. Unfortunately many of our 91,000 school buildings lack this flexibility, and this compromises a child's education.

Optimum School Size

Whether we like it or not, bigness is a pervasive part of our culture: growing population, bigger houses, cars, and schools. Consolidation of schools has been taking place for a long time in this country — from more than 250,000 schools in the 1930s to 91,000 today. Almost all of the downsizing in the past has been accomplished by closing either very small schools or one-room schools. In the past decade, however, we have seen consolidation of larger and larger schools to form mega-schools.

Today, high-school enrollments of more than 2,000 are common, with some schools exceeding 5,000 students. While educators and administrators disagree about optimum school size and how school size alone affects student achievement, research has shown that smaller schools enhance social interaction and influence students in many positive ways. At first this may appear illogical, because larger schools usually offer greater

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[11] Effects of School Lighting on Physical Development and School Performance, Warren E. Hathaway, The Journal of Educational Research, March/ April 1995 Vol.88 (no.4)

[12] Summary of research on the effects of lighting on learning grouped under the title "Influence of the School Facility on Student Achievement-Visual (lighting and color) University of Georgia

[13] Projections of Education Statistics to 2010, National Center for Education Statistics NCES 2000-071

[14] A Vision for Tomorrow's Schools, C. William Day, KBD Planning Group, 2000; Schools for the 21st Century Are you Ready?, Prakash Nair, www.designshare.com; The jewel of the Community, R Fanning & C. Howey, American School and University, January 2000

opportunities in extracurricular activities and specialized courses and thus provide students with a more stimulating environment.

Though some students seem to learn quite well in large schools, a growing body of research shows a greater number of positive advantages for the majority of students in smaller schools. These include higher attendance rates, greater participation in extracurricular opportunities, fewer problems in social behavior, and activities associated with higher student performance like team teaching, frequent teacher interaction and assessments, and cooperative group learning. Smaller schools also graduate a higher percentage of students, and more of those students attend postsecondary schools.

Whether we like it or not, mega-schools will be with us for a long time. And a number of concepts applied to overcome the problems of bigness, such as schools within school's (literally more than one school within a large facility) or student academies (class grouping by field of interest) have not yet equaled the advantages found in smaller schools. Some state legislatures are beginning to react to problems generated by oversized schools by developing size recommendations or passing restrictions.[15] One of the first States to do so, Florida, passed a law requiring smaller new school facilities. The law requires that schools built after July 1, 2003, be limited in size, with high schools limited to 900 students. Other state legislatures are beginning to review and develop similar approaches.

Relocatables

School enrollments in some areas of the country are still growing substantially. And with the average new high school costing $26 million to build, it is not surprising to see school districts purchasing record numbers of prefabricated classrooms, commonly called relocatables or portables, to keep classrooms from bursting at the seams. These structures can have a profound impact on a child's education. About a third of our schools use portable classrooms and about one fifth use temporary instructional space such as cafeterias and gyms, etc.[16]

Relocatables have improved greatly since the early "off-the-street" trailers first employed, and they undoubtedly meet a temporary need. Usually acquired through group district purchases at the lowest price, relocatables are often the weakest link in the educational facility chain — a generally austere solution built to minimal standards — the quick fix that too often becomes permanent.

Not all portable classrooms are bad, but most have inherent problems that are difficult to solve. Relocatables often incorporate materials that off-gas formaldehyde, a significant health-risk for some individuals. They are generally located away from the main school facility and sited on inadequately prepared fields where walking and lighting are poor. Or they are placed on parking lots, which have their own attendant problems. Students and teachers must transfer not within a building but between buildings for restrooms, media centers, gym classes and other specialized classrooms such as art, science, and music. All relocatables, whether they are the most basic structures or something substantially more, require high maintenance.

Relocatables, of course, can be purchased with quality design and materials, and can be clustered in such a manner as to overcome a number of their inherent handicaps; but frequently, this doesn't happen.

If relocatables are required, (the industry estimates a projected growth rate of 20 percent per year) parents should insist that adequate resources, including time, money, and maintenance, be allocated also. And their use should be limited. In Florida, the typical, supposedly temporary relocatable classroom, is 19 years old. Some are aged 40. Many other states have similar experiences.[17]

Conclusion

While it has been said, "A good teacher can teach anywhere," a growing body of research literature also strongly suggests a direct relation between the condition and utility of the school facility and learning. The classroom is the most important area within a school. It is here that students spend most of their time, hopefully in an environment conducive to learning. Learning in the classroom requires a reasonable level of concentration,

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[15] How to Fix America's Schools, BusinessWeek Online March 18, 2001, Reducing the Nagative Effects of Large Schools, D. Duke & S. Trautvetter, National Clearinghouse for Education Facilities Washington D.C.; Great City Schools Issue Paper: School Size, Wisconsin Education Association Council 2001, School Improvement Series, Close-up No. 20, School Size, School Climate, and Student Performance, Kathleen Cotton, Northwest Regional Educational Laboratory, 101 SW Main, Ste. 500, Portland, OR 97204

[16] Condition of America's Public Facilities: 1999 U.S. Department of Education , National Center for Education Statistics, NCES 2000-032

[17] Studyin' Trailers, M Roman, Commercal Modular Construction March/April 2001

listening, writing, and reading. Individual classrooms and entire facilities need to be evaluated, not only on how they meet changing educational requirements, but also on how they meet the environmental requirements for health, safety, and security.

According to a report from the American Association of School Administrators, "Students are more likely to prosper when their environment is conducive to learning. Architecture can be designed to support greater safety and security. Environmentally responsive heating, air conditioning and ventilating systems, for example, either in a new or renovated school, provide a more comfortable learning environment. Such well-designed systems send a powerful message to kids about the importance their community places on education."[19]

There are many elements, ranging from community involvement to educational leadership, that influence the condition of the school facility. None of these elements operate in isolation.

The links connected to student achievements are subtle, but there is enough data and evidence to draw some pretty convincing conclusions. A number of research studies suggest a strong link between the condition of the school building and community involvement and support. As early as 1982 a report that reviewed 88 published studies concluded that old and obsolete buildings have negative consequences for the learning process while safe, modern, controlled environments enhance the learning process.[19]

Four recent studies[20] that evaluated the relationship between school buildings and student achievement found higher test scores for students learning in better buildings and lower scores for students learning in substandard buildings. One of the more recent of these studies showed a difference in student test scores ranging from 5 to 17 percentile points. "Facility condition may have a stronger effect on student performance than the combined influences of family background, socio-economic status, school attendance, and behavior." This comment comes from a recent report evaluating school facilities in Milwaukee, completed by the Council of Educational Facility Planners International.

While additional and more detailed studies will provide a better measure of the correlation, we already have enough evidence to conclude that a relationship exists. If we can agree that public education is a primary concern of the nation, why shouldn't we solve the problem of poor classroom conditions and improve our children's learning opportunities now?

As with everything else, as long as the average citizen thinks schools are doing well, ignorance or apathy will continue to be pervasive. We need to inform ourselves about the condition of our school buildings — and appreciate the important difference a facility can make in educating our children.

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[19] *Preparing Schools and School Systems for the 21st Century, Pg. 53, American Association of School Administrators, 1999 ISBN 0-87652-235-5*

[19] *Studies showing a relationship between student achievement, community support and physical condition of the school building: Chan, T. C. (1996) Environmental Impact on Student Learning. Valdosta State College. ; Earthman,G.I., & Lemasters, L.K. (1996). Review of Research on the Relationship between School Buildings, student achievement, and student behavior. PEB Exchange February 30, 1997 , Lackney, J.A. (1999) Assessing school facilities for learning/ assessing the impact of the physical environment on the educational process: Integrating Theoretical issues with practical concerns. Mississippi State, MS: Educational Design Institute, Mississippi State University., Maxwell, L.E. (1999). School Building renovation and student performance: One District's experience. Edwards Maureen M. (1992) Building Conditions, Parental Involvement and Student Achievement in the D.C. Public School System, Washington D.C. Unpublished Master Degree Thesis Georgetown University. (ED 264 285); Cash Carol (1993) A study of the Relationship Between School Building Condition and Student Achievement and Behavior Blacksburg, Va., unpublished doctoral dissertation, Virginia Polytechnic Institute and State University; Earthman Glen I., Cash, Carol S., Van Berkum, Denny (1995) A Statewide Study of Student Achievement and Behavior and School Building Condition. Presentation at annual meeting Council of Educational Facility Planners International, Dallas Texas, September 19, 1995; Hines, Eric (1996) Building Condition and Student Achievement and Behavior. Blacksburg Va. Unpublished Doctoral dissertation, Virginia Polytechnic Institute and State University*

[20] *The Impact of School Building Condition and Student Achievement and Behavior G. Earthman, Paper presented at the European Investment Bank, Organization for Economic Coordination and Development International Conference Luxembourg, November 16-17 1998; Where Children Learn: Facilities Conditions and Student Test Performance in Milwaukee Public Schools, L. Morgan, Council of Educational Facility Planners International, December 2000; The Relationship Between Environmental Quality of School Facilities and Student Performance, A Congressional Briefing to the U.S. House of Representatives Committee on Science, J. Lackney, Mississippi State University, September 23, 1999; Where Children Learn: The Effect of Facilities on Student Achievement, D. Moore and E. Warner, Council of Education Facility Planners International, December, 1998*

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